

VIRGINIA GIS REFERENCE BOOK

General Application Name: Public Works/Service Authority

Product / Service / Function Name: Storm Water Drainage System Inventory

P/S/F Description:

A storm water drainage system is designed to collect and reroute the precipitation that accumulates in natural or artificial storage systems during and immediately after a storm. There are several types of features that make up the drainage system. In order to maintain an efficient system, these features should be located and inventoried. The inventory process includes physically locating all storm water drainage features and noting their locations as well as gathering the descriptive information about each feature (e.g. size). An up-to-date storm water inventory is also crucial for many storm water applications such as EPA permitting for the National Pollutant Discharge Elimination System (NPDES), modeling, and master planning. Data collected in a storm water inventory can easily be integrated into an existing or new GIS application.

A relatively new mandate called the Governmental Accounting Standards Board Statements Number 34: Basic Financial Statements – and Management Discussion and Analysis – for State and Local Government (GASB 34), will make government asset inventories, including storm water system inventories, directly useful for government accounting. GASB 34 redefines the accounting standards for state and local governments. Organizations must either calculate the historic cost of each asset minus its depreciation through time, or develop an infrastructure asset inventory and management system that will generate an accurate inventory of all assets, report the condition of assets every three years, and determine the annual estimate of the cost needed to maintain the asset in its current conditions. Because of its unique ability to relate individual components and their attributes to specific locations, GIS is well suited for creating and maintaining detailed, auditable infrastructure inventories.

Product / Service / Function

1. Spatial Data -

Minimum Data Requirements

General Description	GIS Data Layer
Storm Water Data	Channels
	Culverts
	Pipes
	Manholes/Junction Boxes
	Pipe Inlet/Outlet
	Catch Basins
	Inlets
	Bridges
	Spillways
	Swales
Natural Features	Streams
	Lakes
Transportation	Right-of-way and/or edge of pavement

	Road centerlines
Socio-Political Data	Municipal boundaries
	Land Use

Optional Data Requirements

General Description	GIS Data Layer
Storm Water Data	Pipe cross-sections
Planimetrics/Base Mapping	Orthophotography
	Zoning
Natural Features	Vegetation
	Flood zones
Transportation	Railroads
Socio-Political Data	Neighborhoods & Subdivisions

2. Attribute Data –

Minimum Attribute Requirements

GIS Data Layer	Attributes
Channels	Feature ID
	Manning's Roughness Coefficient
	Right/Left overbank slope
	Channel geometry
	Up invert elevation
	Depth of channel
	Top width of channel
	Bottom width of channel
	Upstream feature ID
	Downstream feature ID
Culverts/Pipes	Feature ID
	Height
	Width
	Shape
	Material
	Rim Elevation
Manholes/Junction Boxes	Feature ID
	Depth
	Radius/size
	Rim Elevation
Pipe Inlet/Outlet	Feature ID
	Elevation
Catch Basins	Feature ID
	Depth
	Radius/Size

Inlets	Feature ID
	Overall Condition
	Grate Condition
	Material
Bridges	Feature ID
	Road Name
Spillways	Feature ID
	Description
	Size
Swales	Feature ID
	Description

Optional Attribute Requirements

GIS Data Layer	Attributes
Channels	Condition
	Flow (high, low, etc.)
	Water Color
	Odor
Culverts/Pipes	Upstream Invert Elevation
	Downstream Invert Elevation
	Condition
	Flow (high, low, etc.)
	Water Color
	Odor
Manholes/Junction Boxes	Condition of Structure
	Private Tie Ins
	Material
	Surrounding Condition
	Steps
	Stilling Basin
Pipe Inlet/Outlet	Evidence of Scour
	I/O Configuration (mitered, flared, etc.)
	Percent Obstructed
Catch Basins	Condition/Description
Inlets	No. of Private Tie Ins
	Steps (Y/N)
	Surrounding Condition

3. Data Acquisition Options (integrated with VBMP digital orthos)

There are three ways in which storm water features can be identified. In most cases, a combination of the three techniques is used. The first place to consult is the original drawings, site plans, or as-builts, if any, for the drainage system. These original maps are a starting point for determining how many features are in the system. A second technique is to use the VBMP orthophotos to visually identify the drainage features. Not all will be found this way but some

features such as curb inlets or yard drains can be identified on orthos. The larger scale of the orthophotos (such as 1:100'), the more detail can be seen. Finally, with preliminary information gathered from original maps and the VBMP orthos, a Global Positioning Systems (GPS) survey can be conducted to inventory all of the features. It would be a wasted effort to send GPS crews to accurately locate the features without knowing first where to look. The local government agency may be able to conduct this survey on their own, depending on the size of the municipality. However for larger cities, it is likely a better option to hire a GPS consultant for the task.

Base mapping and planimetric data are typically generated at the county or city level. This data may be produced in-house or the project may be contracted out to a consulting firm. This data often includes tax parcels, zoning districts, land use, parks, open water, right-of-ways, railroads, and building footprints. Street centerline data layers of varying qualities can be obtained from a number of vendors. The market is relatively competitive, and prices will vary with quality of the data. Relevant vendors that provide this kind of spatial data on a regional and national scale include: NAVTECH <www.navtech.com>, GDT <www.geographic.com>, and TeleAtlas <www.teleatlas.com>.

Other spatial data layers can be obtained through the Internet from various government sources. Municipal boundaries and similar layers can be obtained in digital format through the U.S. Census Bureau <www.census.gov>. Floodplains can be obtained through the FEMA Web site <www.fema.com>.

Regardless of the source of the data, each data layer used to build the storm water inventory should be consistent with, or be modified to match, the Virginia Base Mapping Project orthophotography. This is vital for data consistency across the state and facilitates data sharing across jurisdictional boundaries. The digital orthophotography provides an excellent base data layer on which to display the storm water drainage system and create map books for field use.

4. Data Conflation Options (integrated with VBMP digital orthos)

Data conflation is a process by which two digital data layers, usually of the same area at different points in time, or two different data layers of the same area, are geographically “corrected” through geometrical and rotational transformations so that the different layers can be overlaid on one another. Also called “rubber-sheeting,” this process allows a technician to adjust the coordinates of all features on a data layer to provide a more accurate match between known locations and a few data points within the base data set. A good base layer to use for data conflation is the VBMP orthophotos since many features can be seen or interpreted. The need and processes for conflation varies between sets of data, users, and feature types. Any dataset that is updated independently by different departments can be consolidated through conflation. Within most local governments, individual departments are responsible for maintaining specific datasets within their expertise; therefore, conflation is not often necessary. Often, reprojecting the data into a different coordinate system will take care of the misalignment of different data sets. Most industry-standard GIS software has the ability to perform data conflation.

Most industry-standard GIS software has the ability to perform data conflation. In the case of a storm water feature inventory, is important to either capture the storm water features in the same projection as the VBMP orthophotography or reproject it later to match the orthophotos. This ensures that when the locations are converted into a GIS data layer, the features will appear in the correct location on top of the orthophotos.

5. GUI / programming options

There are many options for developers of a storm water inventory system. Three possibilities are:

- Standard GIS desktop application that can be customized to the user's needs
- Existing commercial storm water inventory and mapping system
- Hiring a consultant to develop a custom system from scratch

Using a standard GIS software package often requires a significant amount of training and customization. Whereas the initial cost may be lower, the time invested in learning these solutions may generally increase the overall expense of implementation. However, standard GIS software packages deliver more robust data integration, analysis, and cartographic capabilities than do other specialized commercial applications. They have a greater user support infrastructure that allows users to overcome problems quickly. Options for using an existing, industry-standard GIS software application that can be customized for a storm water inventory system include those listed in the following table:

Standard GIS Software Vendors:

Vendor	Software	Web Address
ESRI	ArcView 3.x	http://www.esri.com
ESRI	ArcGIS 8.x	http://www.esri.com
MapInfo	Professional 7.0	http://www.mapinfo.com
Intergraph	GeoMedia 5.0	http://www.intergraph.com/gis
Autodesk	Map 5.0	http://www.autodesk.com

There are an increasing number of vendors developing and implementing utilities management software, including components for storm water inventory. These products may often cost more than standard GIS solutions because of the customization that is required to fit the application into the agency's business practices and/or connect to its data source. The advantage is that a tailored application provides just the functionality that is needed, decreasing the overall application overhead common to industry-standard GIS software. Options for using an existing, commercial storm water inventory system include those listed in the following table:

Commercial Software:

Vendor	Product	Web Address
Azteca	CityWorks	http://www.azteca.com
CarteGraph	WATERview	http://www.cartegraph.com
Hansen	Hansen 7.5	http://www.hansen.com
GBA Master Series	GBA Storm Master	http://www.gbamasterseries.com/

The final option for developing and implementing a storm water inventory system is to contract with a consultant. This option makes certain that a product will fulfill an agency's requirements. Unlike the first option, which requires the user to modify its own process/technology to fit the GIS system, with customized solution, the system fits existing business practices. A consultant will be able to develop an application that works with the wide range of hardware and software that are currently in use within local governments within Virginia. Also, training and follow-up user support is often provided at a much more substantial level than with other options.

Generally, a storm water inventory mapping system will include the ability to view the GIS interactively by allowing users to query for specific features and produce reports. For example, to identify all pipes that were installed before 1970 from old maps would take hours of research. But in a GIS-based storm water inventory, the user would simply query the GIS database for all pipes older than 1970 and display these features on the map. A custom application for storm water may also include functionality to run modeling or generate work orders.

6. Internet Functionality and options

The Internet has proven itself as a viable solution for local governments to centralize the maintenance and management of services and data. As more local governments are implementing Web-based solutions, they are finding that the Internet requires them to change the nature of an application or its usefulness. Through the flexibility of an Internet solution, software can be easily updated, and users gain greater accessibility to the applications and information they need for their specific tasks through simple, user-friendly interfaces.

If a local government so chooses, they can deploy a Web GIS application to allow citizens of their community to view maps of the storm water drainage system or the progress of the inventory itself. GIS software vendors have products that can be customized in-house or by a consultant to provide Web GIS applications on the Internet, over an intranet or via wireless network. The table below shows GIS vendors and their Internet mapping solutions.

GIS Internet Solutions

Vendor	Internet Software	Web Address
ESRI	ArcIMS	http://www.esri.com/software/arcims
MapInfo	MapXtreme, MapX	http://www.mapinfo.com
Intergraph	GeoMedia WebMap	http://www.intergraph.com/gis/gmwm
Autodesk	MapGuide	http://www.autodesk.com

7. Technical Requirements

Minimum Technical Requirements

At its most basic level, a GIS-based storm water drainage inventory system can be used on a single, stand-alone workstation. This workstation would have a hard drive that stores all of the spatial data layers, as well as the GIS software package or application itself. A typical workstation running off-the-shelf software should have the following minimum specifications:

Processor: Pentium 3; 450 MHz
 RAM: 128MB SDRAM at 133MHz
 Hard Disk: 20GB (min.)
 Monitor 1: 19"
 Floppy Drive: 3.5"
 CD-ROM: 12x/8x/32x CD drive
 Modem: 56K
 OS: Windows 2000/NT/XP
 Office: Windows 2000 Professional
 Printer: 8x11 office-grade color printer

Optimum Technical Requirements:

A more complex storm water drainage system may require multiple components, including servers, desktop workstations, or ruggedized laptops, or handheld devices. The scale at which the system is implemented, thus the technical needs, is dependent on the number of daily GIS users as well as the number of data collectors. For either a client-server or a Web-based application, the system should rely on a fairly robust server computer and high-end workstations. Some examples specifications of the necessary equipment are listed below:

Server

Processor: Min. 2x Processors, 1.7 GHz, 512K cache
RAM: Min. 2x 512MB RIMMS
Hard Disk: Min. 2x 80GB +RAID
Monitor 1: 19"
Floppy Drive: 3.5"
CD-ROM: 12x/8x/32x CD drive
Modem: 56K
Network Card: 10/100 mbps

Workstation

Processor: Pentium 4, 1.5 GHz
RAM: 512MB SDRAM at 133MHz
Hard Disk: 20GB (min.)
Monitor 1: 19"
Monitor 2: 17"
Floppy Drive: 3.5"
CD-ROM: 12x/8x/32x CD-RW drive
Modem: 56K
Network Card: 10/100 mbps
OS: Windows 2000/NT/XP
Office: Windows 2000 Professional

Other Components

Printer: 8x11 office-grade color printer and 8x11 production b/w printer
Plotter: HP DesignJet 1055CM
Tape Backup: Tape Library Server
UPS: APC 1400 (or other similar)
Scanner: 11x17
Handheld: Compaq IPAQ
Network: T1

8. Administrative/Management Requirements

Essentially, there are two major tasks to consider for a storm water drainage inventory. First is the actual inventory itself and the second is the development of the GIS based on that inventory. At the beginning of the project, the assigned project manager from the particular municipality should consider completing some, if not all of the following tasks that relate to the administrative requirements of a storm water inventory system:

- Determine, with or without the assistance of a consultant hired to develop the system, the preliminary vision and goals of the project.
- Coordinate an initial meeting with the decision-makers (i.e. the Board of Supervisors, public works department, engineering department, etc.) where the vision and goals of the project are expressed and the background of GIS technology is described, if needed.

- Coordinate with other municipal agencies for data sharing provisions.
- Determine a mechanism of communication to keep the decision-makers aware of the progress of the project.
- Develop a basic understanding of the available precedents in the region/state and research the available technologies that can be applied to the project.

Upon project completion, a simple desktop storm water drainage inventory system will require very little administrative support. Administrative tasks may include loading or upgrading new versions of the software or patches, providing for constant data flow from the source database, and maintaining yearly support contracts on the hardware and software. However, once the system becomes distributed as an enterprise solution to many users throughout a department or deployed on the Internet, there are various other management requirements that need to be fulfilled on a weekly or monthly basis.

At the point where the system grows beyond single desktop users, a devoted administrator or system manager needs to be established. This is essential for the following reasons:

- The system will now be interfacing with other technology systems already in place. Therefore, someone needs to maintain contact with the technology personnel that maintain these systems.
- The manager needs to put into place training schedules to maintain user knowledge of the system.
- Funding will undoubtedly be required to either maintain the system long-term, or continue to expand the system, which requires funding research and applications for grants.
- A storm water drainage inventory system will only succeed when it is maintained on a predetermined schedule with rigorous analysis and planning.

9. Cost – Cost/Benefit

Hardware	Typical Unit Cost
Minimum Workstation	\$2,000
Optimum Workstation	\$3,200
Laptop	\$2,400
Web/FTP Server	\$8,500
Database Server	\$12,000
Data Warehouse Server	\$18,000
Backup Server	\$5,800
Printer (8x11 color)	\$700
Printer (8x11 b/w production)	\$2,000
Plotter	\$12,000
Tape Library	\$5,000
UPS (Universal Power Supply)	\$700
Scanner	\$1,500
Handheld	\$300-\$700

Software (all prices included license)	Typical Unit Cost
Standard GIS desktop software	\$700-\$10,000
Customized desktop vendor solution	\$5,000-\$15,000

Web-based vendor application	\$15,000-\$25,000
Customized web-based vendor solution	\$20,000-\$60,000

Miscellaneous	Typical Unit Cost
GPS consultant survey	\$15,000-\$90,000 (depends on system size)
Training – focused vendor crime mapping training (per person)	\$700-\$1,000
Training – general GIS	\$700-\$1,200
Licensing – desktop	\$100-\$500
Licensing – webapp (1st CPU)	\$7,500-\$12,000
Maintenance (per year)	\$8,000-\$15,000

10. Standards / Guidelines Summary

- Research the historical documentation for the location of the storm water drainage features before establishing a budget. Budgeting on a per meter basis could case the project to run over if there are more features in the field than anticipated.
- Create a realistic schedule for the GPS survey. Consider the amount of effort as well as data accuracy requirements and number of features.
- Do a “pilot area” first to review initial data collected to see if a revised plan is needed before moving on to the rest of the inventory.
- Develop a detailed Quality Assurance/Quality Control (QA/QC) procedure for reviewing the accuracy of the storm water feature locations and their attributes.
- Consider inventorying other utilities at the same time the storm water features are located with GPS. This is a potential cost savings.
- Standardize data entry and editing procedures. Data entry procedures will need to be integrated with staff work routines to promote accurate and reliable spatial and attribute data when developing new data sets or updating existing datasets.
- Maintain data in the VBMP standard coordinate system (Virginia State Plane, NAD 83, Survey Feet).
- Create metadata (standard information about GIS data) for each data layer. Metadata tracks the date, origin, coordinate system, and other such information for data layers.

11. Startup Procedures/Steps

A storm water drainage inventory is a very large project; therefore, careful planning will make the process go more smoothly. There are at least eight steps involved with doing the inventory and developing a GIS-based storm water system. The steps can be performed in-house or by a consulting team.

The first task is to complete a detailed Needs Assessment. This process gathers information regarding existing operational procedures, hardware and software, GIS data, and personnel needs. It should include interviews of key individuals throughout the local government agency and other related government departments to obtain a comprehensive view of the agency’s operations, and where GIS might improve them. Basic GIS concepts should be discussed and illustrated to those interviewees that have little prior understanding of GIS. A comprehensive Needs Assessment should then be compiled from the results of the interviews. This document explains the various requirements for a storm water drainage inventory system in the following areas: personnel needs, spatial data development needs, applicable spatial analysis techniques, basic system

requirements, including preliminary, general hardware and software recommendations, and training needs.

The second task is to develop a functional requirements document for the proposed system. This document should describe, as completely as possible, all of the technology and functionality that is to be included in the system. This document is used by the local government agency, or its consultant, as the blueprint for the GIS application or system. It should include:

- Hardware specifications
- Software purchases
- Detailed descriptions of work-flow, and examples of the graphic user interfaces
- Describe each tool that is part of that graphic user interface, and its functionality
- Describe how data would flow between the different databases and data warehouses, if applicable
- Describe the redundant security measures that will be put in place to make certain of data integrity and confidentiality, when applicable
- Analytical techniques that the application/system provides
- Describe each of the potential products (reports, maps, charts, summary tables) that the user will be able to generate within the system

The third task should be to compile or develop a storm water spatial data set that can be used by the evolving storm water drainage inventory system. Underlying data can be gathered from a number of online sources, as well as county/city departments. The data layers gathered and maintained should match at least the minimum list provided in Section 1 of this document. At this point, the GPS survey of drainage features should begin.

On completion and acceptance of the functional requirements document and the development of the spatial and attribute data, the system development and test phase can begin. During this time, the application will be customized as it was outlined in the functional requirements phase. The local government agency should require periodic reviews of the application at particular milestones, such as 50% and 75% completion. This will make certain that problems with the application will be recognized early in the development process, and that the local government agency remains a part of the development process throughout the project timeline.

When the system is nearing 100% completion, it should be installed and tested in the environment in which it will ultimately be used. This allows the users to test the system alongside the application developers, and determine any system integration problems that might arise. It also gives the developers the opportunity to test the application's functionality in a real-world situation. This testing process should be as comprehensive as possible. Each process detailed within the functional requirements should be tested and evaluated at this point.

User training commences once the application reaches 100% completion and is fully documented. Different levels of tutorials and system documentation should be developed depending on the hierarchy of users. Time should be spent at this stage of the project with each potential user of the system to make certain that the proper education occurs. Training should be done through lessons that use real-life examples of system application. This strategy greatly enhances users' ability to apply the functionality to their jobs.

The next phase of the project should include a document that describes a future plan for wider system development. This document accomplishes two goals. The future plan gives the local

government agency ideas on how the system might grow to assist other facets of its business practices. Secondly, it provides the agency with a ready-made grant proposal for applying for potential funding sources.

The final phase of a successful storm water drainage inventory system is ongoing technical support. The local government agency should always include this contingency within its cost estimates of a project for a minimum of three months after a system has been put into place. No matter how effective an application appears, problems and system changes inevitably impact the functionality of a system.

12. Estimated time line and/or implementation (stand alone) schedule

Phase	Approximate Duration
RFP/Contract process (construction, posting, proposal acceptance, review, award of contract)	4 months - 1 year
Needs Assessment	2 months
Functional Requirements	1-2 months
Data Development	6-12 months
System Development and Testing	2-4 months
Installation and Testing	1 month
User Training	½ month
Plan for Future Development	½ month
Ongoing Support	3 months

13. Best Practice Examples in Virginia

Henrico County
 4301 E. Parham Rd
 Richmond, VA 23228
 (804) 501-5769
www.co.henrico.va.us/devsite/gisstatus.html

Price William County
 4361 Ridgewood Center Drive
 Prince William, VA 22192,
 703- 792-6666
<http://www.co.fairfax.va.us/living/publicworks/default.htm>

City of Hampton
 Public Works
 22 Lincoln Street, 4th Floor
 Hampton, VA 23669
 757-727-8311
www.hampton.va.us/publicworks/engineering_services_gis_services.html